MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2016/2017

PPH0105 – MODERN PHYSICS & THERMODYNAMICS

(All sections / Groups)

26 MAY 2017
3.00 p.m – 5.00 p.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 4 pages (excluding physical constant and formula list) with 5 Questions only.

2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Instructions: Answer **ALL** questions in this section. Write your answers in the Answer Booklet.

Question 1

(a) A sinusoidal wave travelling in the positive x direction that has an amplitude of 15.0 cm, a wavelength of 40.0 cm, and a frequency of 8.00 Hz. The vertical position of the wave at $t = 0$ and $x = 0$ is also 15.0 cm. Find

(i) the wave number k, [2 marks]

(ii) the angular frequency ω of the wave. [2 marks]

(iii) Write a general expression for the wave function. [1 mark]

(b)

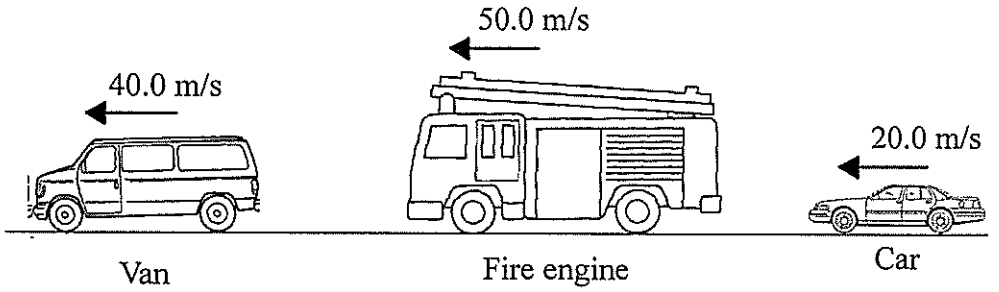

Figure Q1(b)

Three vehicles move to the left with their speeds shown in **Figure Q1(b)**. If the fire engine sounds its siren at a frequency of 500.0 Hz, determine the frequency of the siren as heard by:

(i) The driver of the fire engine. [1 mark]

(ii) The driver of the van. [2 marks]

(iii) The driver of the car. [2 marks]

(The speed of sound in air is 340.0 m/s)

Continued...

Question 2

(a) A converging lens with a power of 5 D produces a magnified image of an object. The image is 0.6 m from the centre of the lens and upright with respect to the object.

(i) State another one property of the image. [1 mark]

(ii) Calculate the focal length of the lens. [1 mark]

(iii) Determine the position of the object from the lens. [1 mark]

(iv) Draw a ray diagram to show the formation of the image. Label in your diagram the positions of object (O), image (I) and focal points of the lens (F). (Note: A scale diagram is not required) [2 marks]

(b) **Figure Q2(b)** shows plane wave fronts incident on a narrow slit from the left and diffract as they emerge on the right hand side of the slit.

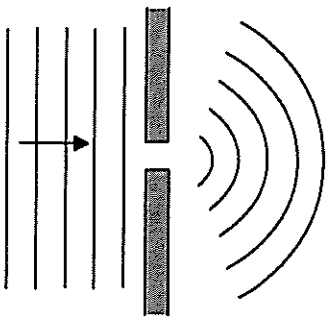

Figure Q2(b)

(i) What is meant by the diffraction of a wave? [1 mark]

(ii) State the principle that explains diffraction in **Figure Q2(b)**. [1 mark]

(c) A monochromatic light with a wavelength of 500 nm incident normally on a diffraction grating which has 3000 lines per centimeter.

(i) Determine the angle of diffraction for second order maximum. [1 mark]

(ii) How many maxima are seen in the pattern on the screen? [2 marks]

Continued...

Question 3

(a) In the reactor of a nuclear power station, a uranium nucleus is bombarded by a slow neutron as shown in the **Figure Q3(a)**:

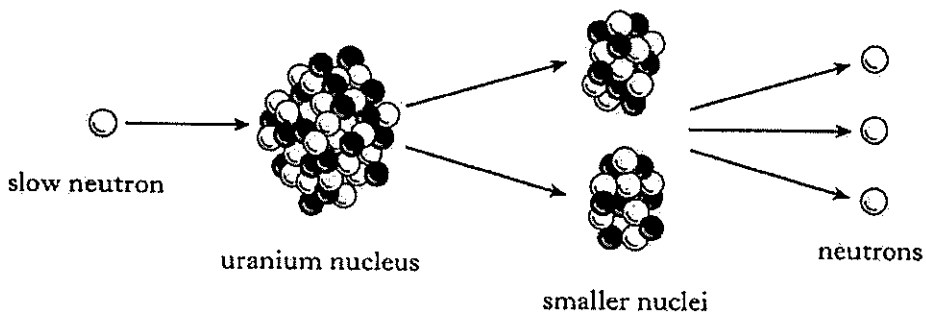

Figure Q3(a)

(i) A nucleus contains two types of particles. Name these particles. [1 mark]

(ii) What is the name given to the process as shown in the **Figure Q3(a)**. [1 mark]

(iii) In this reaction, neutrons are released. Why are these neutrons important to the operation of the reactor? [1 mark]

(iv) Complete the equation for the above nuclear reaction and the values for X and Y:

$$^{235}_{92}U + ____ \rightarrow {}^{141}_{56}Ba + {}^{X}_{Y}Kr + ____$$

[3 marks]

(b) The ^{216}Po nucleus is unstable and exhibits radioactivity. It decays to ^{212}Pb by emitting an alpha particle, which is a helium nucleus, ^{4}He. The relevant masses are: $^{216}Po = 216.001905$ u, $^{212}Pb = 211.991888$ u and $^{4}He = 4.002603$ u.

(i) Find the mass change of the system in this decay. [2 marks]

(ii) Find the energy this mass change represents. [2 marks]

Continued...

Question 4

(a) The work function for platinum is 6.35 eV. Ultraviolet light of wavelength 155 nm is incident on the clean surface of a platinum sample. We wish to predict the stopping voltage we will need for electrons ejected from the surface.

(i) What is the photon energy of the ultraviolet light? [1.5 mark]

(ii) How do you know that these photons will eject electrons from platinum? [1.5 mark]

(iii) What is the maximum kinetic energy of the ejected photoelectrons? [1.5 mark]

(iv) What stopping voltage would be required to arrest the current of photoelectrons? [1.5 mark]

(b) As a hydrogen atom undergoes a transition from the n = 3 state to the n = 2 state, a photon is emitted.

(i) Calculate the energy of the emitted photon. [2 marks]

(ii) Calculate the wavelength of the emitted photon. [2 marks]

Question 5

(a) A steel railroad track has a length of 50.0 m when the temperature is 0 °C. What is its length on a hot day when the temperature is 40 °C?
[Given: average coefficient of linear expansion for steel is 11×10^{-6} °C^{-1}] [2 marks]

(b) Determine the equilibrium temperature when a 245 g block of copper at 300°C is placed in a 150 g aluminum calorimeter cup containing 820 g of water at 12°C.
[Given: c_{copper} = 390 J/kg·°C, c_{water} = 4186 J/kg·°C and $c_{aluminum}$ = 900 J/kg·°C] [2 marks]

(c) 2.0 L of ideal gas at 1 atm undergoes the following processes in a sequent:
(1) The gas are cooled at constant pressure to a volume of 1.0 L
(2) Then the gas expanded isothermally back to 2.0 L
(3) Then its pressure is increased at constant volume until the original pressure is reached.

(i) Determine the final pressure of process (2) above. [2 marks]

(ii) Sketch a PV diagram and label process (1), (2), and (3) accordingly. [2 marks]

(iii) Determine the isothermal temperature in process (2) if the original temperature is T_0. [2 marks]

End of Page

Physical Constants

Acceleration due to gravity	g	=	$9.8\ \text{m s}^{-2}$
Speed of Sound in Air	v	=	$340\ \text{m s}^{-1}$
Speed of light in vacuum	c	=	$3 \times 10^{8}\ \text{m s}^{-1}$
Threshold of hearing	I_0	=	$1.0 \times 10^{-12}\ \text{W m}^{-2}$
Coulomb constant	k	=	$9.0 \times 10^{9}\ \text{N m}^{2}\ \text{C}^{-2}$
Electronic charge	e	=	$1.602 \times 10^{-19}\ \text{C}$
Electron mass	m_e	=	$9.11 \times 10^{-31}\ \text{kg}$
Proton mass	m_p	=	$1.6726 \times 10^{-27}\ \text{kg}$
Neutron mass	m_n	=	$1.6749 \times 10^{-27}\ \text{kg}$
Refractive index of air/vacuum	n	=	1.0
Wein's displacement constant		=	$0.2898 \times 10^{-2}\ \text{m.K}$
Planck's constant	h	=	$6.626 \times 10^{-34}\ \text{J. s}$
Rydberg constant	R_H	=	$1.097 \times 10^{7}\ \text{m}^{-1}$
Avogadro's Number	N_A	=	$6.02 \times 10^{23}\ \text{mol}^{-1}$
Unified atomic mass unit	1 u	=	$1.66 \times 10^{-27}\ \text{kg}$
	1 eV	=	$1.602 \times 10^{-19}\ \text{J}$
Threshold of intensity of hearing	I_o	=	$1.0 \times 10^{-12}\ \text{Wm}^{-2}$
Stefan-Boltzmann constant	σ	=	$5.67 \times 10^{-8}\ \text{J s}^{-1}.\text{m}^{-2}.\text{K}^{-4}$
Universal gas constant	R	=	$8.31\ \text{J mol}^{-1}\ .\ \text{K}^{-1}$
Boltzmann's constant	κ	=	$1.38 \times 10^{-23}\ \text{J K}^{-1}$
	1 atm	=	$1.013 \times 10^{5}\ \text{Pa}$

The energy equivalent of the atomic mass unit is 931.5 MeV

Formula List

$\sin\theta_1 + \sin\theta_2 = 2\sin ½(\theta_1 + \theta_2)\cos ½(\theta_1 - \theta_2)$

$\cos\theta_1 + \cos\theta_2 = 2\cos ½(\theta_1 + \theta_2)\cos ½(\theta_1 - \theta_2)$

$\sin\left(\theta + \frac{\pi}{2}\right) = \cos\theta$

$\sin\theta \approx \tan\theta \approx \theta$ *rad* for small angle

$D(x, t) = D_M \sin(kx \pm \omega t \pm \phi)$

$v = \sqrt{\frac{F_\tau}{\mu}}$ $\quad$ $v = \sqrt{\frac{\text{elastic property of the medium}}{\text{inertia property of the medium}}}$

$\lambda_n = \frac{2}{n}L$ $\quad$ $f' = f\left(\frac{v \pm v_o}{v \mp v_s}\right)$

$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$ $\quad$ $\frac{1}{f} = (n-1)\left\{\frac{1}{R_1} + \frac{1}{R_2}\right\}$

$d\sin\theta = m\lambda$ $\quad$ $d\sin\theta = \left(m + \frac{1}{2}\right)\lambda$

$\lambda_m.T = 0.2898 \times 10^{-2}$ $\quad$ $I(\lambda, T) = \frac{2\pi c k_B T}{\lambda^4}$

$E_n = -\frac{mk^2e^4}{2\hbar^2}\left(\frac{1}{n^2}\right)$ $\quad$ $r_n = \frac{\hbar^2}{mke^2}n^2$ $\quad$ $L = mvr_n = n\hbar$

$\frac{1}{\lambda} = R_H\left[\frac{1}{n_i^2} - \frac{1}{n_f^2}\right]$ $\quad$ $\frac{1}{\lambda} = \frac{mk^2\ Z^2e^4}{4\pi\ c\hbar^3}\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$ $\quad$ $\lambda = \frac{h}{p}$

$R = R_0e^{-\lambda t}$ $\quad$ $\lambda = \frac{\ln 2}{T_{\frac{1}{2}}}$ $\quad$ $Q = (M_X - M_Y - M_\alpha)\ c^2$

$pV = nRT$ $\quad$ $k = \frac{R}{N_A}$

$\frac{\Delta Q}{\Delta t} = -kA\frac{\Delta T}{\Delta L}$ $\quad$ $\frac{\Delta Q}{\Delta t} = e\sigma AT^4$ $\quad$ $\frac{\Delta Q}{\Delta t} = IeA\cos\theta$

$\overline{KE} = \frac{1}{2}m\bar{v}^2 = \frac{3}{2}kT$ $\quad$ $U = \frac{3}{2}nRT$

$Q = \Delta U + W$ $\quad$ $W = \int dW = \int_{V_i}^{V_f} P dV$